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ABSTRACT

This study addressed: (1) what difference, if any, would calculators make on a typical mathematics assessment instrument; (2) what might occur if students were allowed to use, but were not furnished with, calculators for testing; and (3) what implications do answers to these questions have for future statewide assessment. Eighth-grade students were tested using a package from a previous assessment. Three junior high schools in a suburban school district were chosen, with three classes per building assigned randomly to each of three treatments. Control classes were tested without calculators. Classes in the first experimental group were furnished with calculators. Students in the second group were told they were allowed to bring their own calculators over two days prior to testing. Only those pupils in this second experimental group who brought calculators were allowed to use them; only 39% of this group did so, but students in this group who did or did not bring calculators displayed essentially the same achievement. Results across all groups indicated that for the assessment instrument used, calculators made no difference in final results. (MF)

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THE USE AND NON-USE OF CALCULATORS ON ASSESSMENT TESTING

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The Minnesota Department of Education (MDE) has been conducting a program of statewide assessments in various subject areas for about a decade. During this time, mathematics achievement has been measured twice in grades 4, 8, and 11 and achievement in basic skills of mathematics once in grades three through eight. Minnesota results on items from the National Assessment of Educational Progress (NAEP) have compared favorably with national and Upper Midwest regional results.

During this past decade, many changes have taken place and/or proposed in mathematics education. The infusion of computers has multiplied greatly. The profession has advocated an increased emphasis on teaching and learning problem solving. The metric system of measurement has nudged its way into the curriculum, along with discussions about the appropriateness of teaching fractions and decimals. And the hand-held calculator has become increasingly available to students in schools and at home.

While the use of calculators in mathematics classes has been strongly advocated by many leaders in mathematics education nationally, teachers in classrooms have sometimes reflected an opinion voiced by some parents that "kids shouldn't be allowed to use calculators because they need to be able to compute as people always have, with pencil and paper."

There has been considerable research in this field to try to determine whether the use of calculators is harmful or beneficial to students. Some of this research has shown that students using calculators in the classroom learning process, score better than students not using calculators, particularly in problem solving situations (Brey, 1980; Vanatta and Hutton, 1980; Wheatley, 1980; Andersen, 1977; Vaughn, 1977). But the predominant research results indicate no differences in achievement between students using or not using calculators (Herrington, 1980; Miles, 1980; Noone, 1980; Schult, 1980; Toole, 1980; Zink, 1980; Szetela, 1980; Boling, 1977; Borden, 1977; Hutton, 1977; Jamski, 1977; Lenhard, 1977; and Sutherlin, 1977). We could not find results indicating that the use of calculators in classrooms were a detriment to achievement or attitudes.

The NAEP, in its mathematics assessment of 1977-1978 included some testing of students who were allowed to use calculators. Results of that part of the assessment were not published. According to an informal report, students using calculators scored higher on computation items, but performances on problem solving items varied among the different grade levels.

Given all these factors, it might be possible to conclude that sometime in the future the use of calculators in school may be the mode rather than the exception. It would be prudent to plan for such a situation and be ready to "incorporate calculators in the assessment program." With this in mind, we desired some answers to the following:

1. What difference, if any, would the use of calculators make on a typical mathematics assessment instrument?

2. What might we expect if we simply "allowed" students to use a calculator rather than furnish one for the testing?
3. What implications do the answers to the first two questions have for future statewide assessment?

METHOD

We decided to test students in grade eight and to use one of the packages (forms) used in previous eighth grade mathematics assessment. The testing was conducted in a suburban school district. The mathematics supervisor for that district selected three of the five junior high schools and a teacher of multiple eighth grade classes in each. In each school three of these classes were chosen and randomly assigned to each of three treatments for testing. The control groups, C, were given the test without using calculators. The first experimental groups, E₁, were furnished calculators for each student who were allowed to use them for the testing. Students in the second experimental groups, E₂, were told on each of the two days previous to testing, that they could bring and use calculators if they wished. Only those in E₂ who brought a calculator were permitted to use it--no sharing was allowed.

As was the case in the statewide testing, each student was supplied with a test booklet and answer sheets (one for open-ended items, one for closed items). The directions and appropriate parts of the items were read to the students on a paced tape so that the timing for all test situations were identical. Students in each school were tested on the same day. Each treatment was identifiable on the answer sheet and in E₂ each student indicated whether or not a calculator was available.

The test answer sheets were scored by the investigator who also performed the analysis.

RESULTS

The test included 42 cognitive items of which only eight were of a type where a calculator could be used to advantage. The others were either simple recognition of basic facts of arithmetic ($9 \times 4 = \underline{\hspace{1cm}}$, $14 - 8 = \underline{\hspace{1cm}}$, $56 \div 8 = \underline{\hspace{1cm}}$) or items asking geometric or algebraic questions or interpreting symbols, tables or graphs. The eight calculator items were scored separately and then incorporated into the total score.

Table 1 shows the results. The E₂ group is divided into E_{2a}, students with a calculator available and E_{2b}, students without an available calculator.

Means and Standard Deviations of Test Results By Treatment						
<u>Treatment</u>		<u>C</u>	<u>E_{2b}</u>	<u>E₁</u>	<u>E_{2a}</u>	<u>t,p</u>
All items (42 possible)	N	79	46	96	29	
	$\bar{x}$	26.747	26.022	26.427	26.655	
	s	4.63	4.72	4.38	4.25	
<u>Totals</u>		N = 125		N = 125		t = 0
C+E _{2b}	E ₁ +E _{2a}	$\bar{x}$ = 26.48		$\bar{x}$ = 26.48		
(No Calculator)	(Calculator)	s = 4.51		s = 4.46		
Calculator Items (8 possible)	$\bar{x}$	4.949	4.761	5.740	5.276	
	s	1.20	2.07	1.04	2.34	
<u>Totals</u>		$\bar{x}$ = 4.976		$\bar{x}$ = 5.720		t = 5.06
C+E _{2b}	E ₁ +E _{2a}	s = 1.24		s = 1.07		p = .001
Non-Calculator Items (34 possible)	$\bar{x}$	21.608	21.260	20.75	20.90	
	s	3.89	3.74	4.01	4.04	
<u>Totals</u>		$\bar{x}$ = 21.480		$\bar{x}$ = 20.784		t = 1.39
C+E _{2b}	E ₁ +E _{2a}	s = 3.84		s = 4.02		p = 0.08

(TABLE 1)

Of particular interest is the comparison of the results by treatment on the items for which a calculator should be useful. Table 2 shows the numbers of students with correct answers on each of the eight items.

Number of correct answers, item-by-item on eight "calculator-items"				
#	Item	Number correct (N=125)		
		C+E ₂ b	E ₁ +E ₂ a	z
5.	Add 43+71+75+92 (in vertical format)	99	107	1.763*
6.	Subtract 4.78 from 17.5	67	100	5.919*
10.	Divide: 16.4 ÷ .04 = _____	68	97	5.208*
15.	If you spent 72 cents, how much change should you get back from one dollar?	114	113	-0.316
**21.	Multiply: $\begin{array}{r} 773 \\ \times 9 \\ \hline \end{array}$	100	122	4.919*
**29.	Given a menu with prices, find out how much Sue spent for a hot dog, french fries, and milk?	122	120	-1.169
**36.	A box of cereal weighs 336 grams and sells for 63¢. What is the cost per gram to the nearest cent?	38	38	0
**37.	Determine lowest price per ounce, given four different size packages and prices.	13	18	1.465
**	Multiple choice items.	*significant at 0.05 level		

(TABLE 2)

One other bit of information which can be gathered from the data available, is a comparison of the general mathematics achievement of students in E₂a and E₂b. This comparison is in Table 3.

Comparison of results on 32 non-calculator items between students in E ₂ who did/did not bring calculators for the testing.			
	<u>E₂a (calculators)</u>	<u>E₂b (no calculators)</u>	<u>t,p</u>
N	29	46	
$\bar{x}$	20.90	21.26	t = 0.38
s	4.04	3.74	p = 0.35

(TABLE 3)

DISCUSSION

This little investigation was conducted to help determine what effect the use of calculators would have on statewide assessment in mathematics. Eighth grade students were given one package from the 1978 Minnesota assessment of mathematics achievement. Control students did not have access to calculators. One experimental group was issued calculators for the test and the other was allowed to bring and use calculators if desired. For the purpose of interpreting the data, the second experimental group was divided into users and non-users of calculators.

Only 39 percent of the E2 group brought calculators to the testing. This was an unexpected result, since NAEP researchers have found that 80 percent of thirteen year old students in 1977 had access to a hand-held calculator at home (Reys, 1980). The analysis in Table 3 indicates that students in E2 who did or did not bring calculators (E2a versus E2b) have essentially the same mathematics achievement. It would seem from this limited sample that if eighth grade students were instructed beforehand to bring a calculator for taking the assessment test, between a third and a half of the students would bring a calculator. However, it might be well to gather data on this question from a wider sample before depending on this procedure to provide test data from students who use or don't use a calculator.

The data from Table 1 indicates that the use or non-use of a calculator on this test, which is typical of the Minnesota assessment packages at grades 4, 8, and 11, doesn't make any difference in the final result. Students scored at identical levels on the total test, and on items for which a calculator could hardly be useful, the difference between results of the two treatments is not significant at the 5 percent level. So, apparently the students in the groups using calculators and not using calculators have the same general mathematics achievement/ability.

However, on items for which a calculator can be used to advantage, using one will increase the score on those items. This is apparent from Table 1. Furthermore, that conclusion can only be drawn for items of pure arithmetic. In Table 2, the four items for which significant differences are claimed are pure computation. On the others, which could loosely be called problem solving, there is no difference between the results comparing use and non-use of calculators.

It appears from all this data that if a test of mathematics is heavily weighted with computation items, using a calculator will increase the scores substantially. But if the test minimizes the computation aspect and tests more concepts and problem solving, such use will have minimal effect. It should be borne in mind that this investigation did not address the use of calculators to teach students prior to testing. It would be interesting, indeed, to see mathematics (and other, related subjects) test results if the use of calculators is a complete non-issue in curriculum and instruction.

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